PROGRESS REPORT

LOWER YELLOWSTONE RIVER EROSION CONTROL

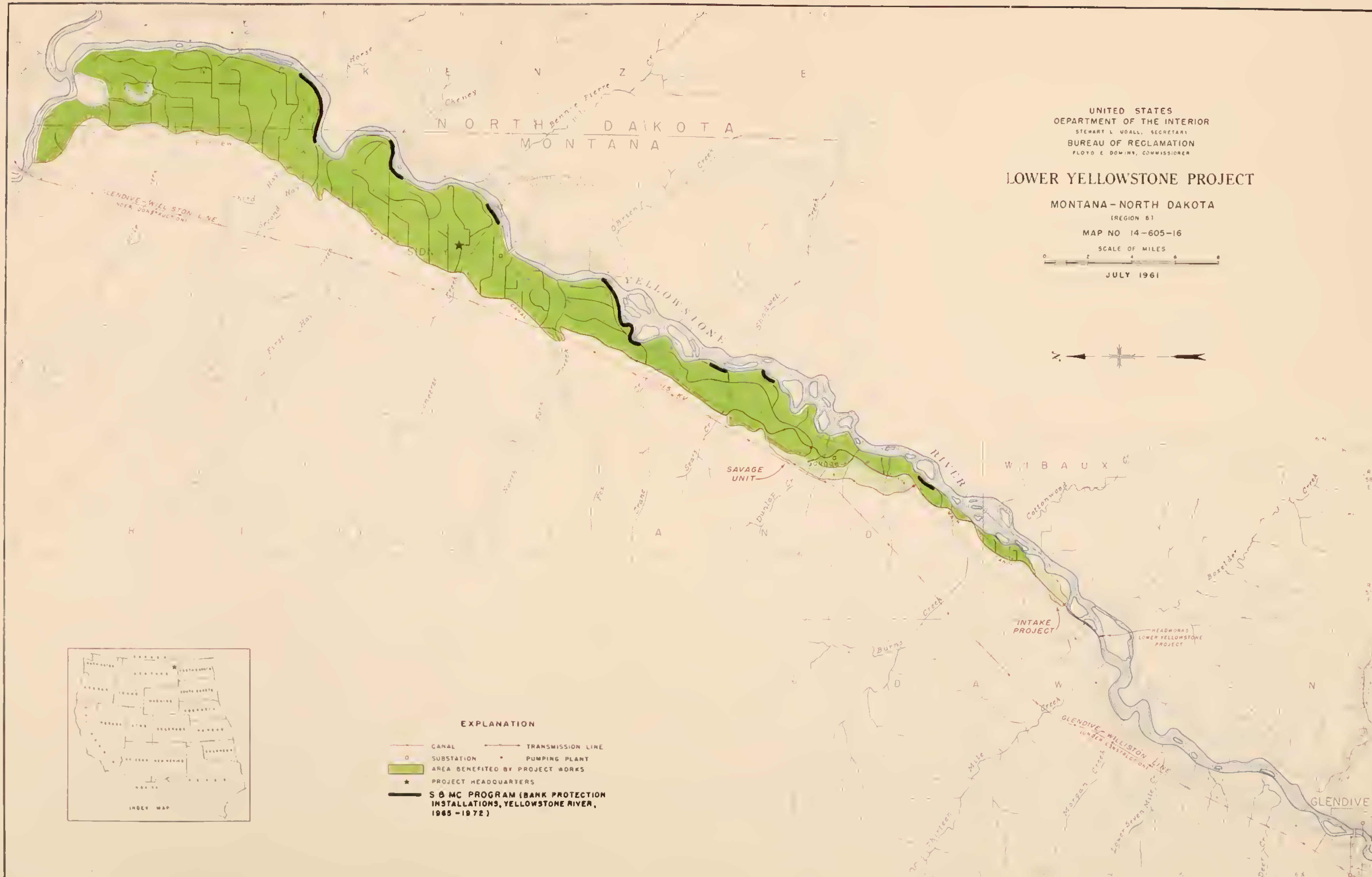
SOIL AND MOISTURE CONSERVATION PROGRAM

Upper Missouri Region, Billings, Montana

Bureau of Reclamation

U. S. Department of the Interior

July 1972


UNITED STATES
DEPARTMENT OF THE INTERIOR
STEWART L. UDALL, SECRETARY
BUREAU OF RECLAMATION
FLOYD E. DOMINY, COMMISSIONER
LOWER YELLOWSTONE PROJECT
MONTANA-NORTH DAKOTA
(REGION 6)
MAP NO 14-605-16
SCALE OF MILES
JULY 1961
NORTH DAKOTA
MONTANA
YELLOWSTONE RIVER
SIDNEY
SAVAGE UNIT
INTAKE PROJECT
HEADWORKS LOWER YELLOWSTONE PROJECT
GLENDIVE-WILLISTON LINE (UNDER CONSTRUCTION)
GLENDIVE
WIBAUX Co.
DAWSON
EXPLANATION
CANAL
TRANSMISSION LINE
SUBSTATION
PUMPING PLANT
AREA BENEFITED BY PROJECT WORKS
PROJECT HEADQUARTERS
S & MC PROGRAM (BANK PROTECTION INSTALLATIONS, YELLOWSTONE RIVER, 1965-1972)
INDEX MAP

FACTUAL DATA ON THE LOWER YELLOWSTONE PROJECT

WATER SUPPLY

The Yellowstone River Basin above the Lower Yellowstone Project diversion dam contains 66,000 square miles and has an average annual runoff of 10,316,000 acre-feet, a maximum of 14,190,000 acre-feet, and a minimum of 5,120,000 acre-feet.

FEATURES OF THE PROJECT PLAN

THE LOWER YELLOWSTONE RIVER PROJECT DIVERSION DAM, located at a point 18 miles below Glendive, Montana, is a rock-filled timber overflow structure about 8 feet high, with a crest length of 700 feet.

THE LOWER YELLOWSTONE PROJECT MAIN CANAL diverts to the west side of the Yellowstone River, and extends down the Yellowstone Valley to the confluence of the Yellowstone and Missouri Rivers. The initial capacity is 1,200 second-feet.

THE THOMAS POINT PUMPING PLANT, located 19 miles below the Lower Yellowstone Project Main Canal headgates, utilizes power generated in dropping water from the Main Canal to Lateral KK to operate 2 turbines direct-connected to centrifugal pumps. The lift is 31 feet and the capacity is 45 cubic feet per second. An additional electric driven pump at 15 c.f.s. capacity was installed in 1960.

LATERAL SYSTEM of 225 miles serves project lands.

DRAINAGE FACILITIES, consisting of 105 miles of drains, have been constructed.

IRRIGATION PLAN

Water is delivered to the individual farms by Irrigation District No. 1, Montana, and Irrigation District No. 2, North Dakota, jointly administered by the Lower Yellowstone Board of Control.

NUMBER OF IRRIGABLE ACRES IN THE DISTRICT

There are approximately 52,068 acres of irrigable land in the project.

CHARACTER OF SOIL IN IRRIGABLE AREAS

The soil is alluvial with silt loams and clay loams predominating.

ALTITUDE OF IRRIGABLE AREA

The elevation of the district averages about 1,900 feet above mean sea level.

DUTY OF WATER

[illegible] for the period from 1927 through 1948.

LENGTH OF IRRIGATION SEASON

Average irrigation season is 163 days, from May 1 to October 10.

ANNUAL RAINFALL

The average annual rainfall is 13.13 inches.

RANGE OF TEMPERATURE

Temperatures have varied from a low of 53° below zero to a high of 111°. The average temperature is 43.4°.

PRINCIPAL PRODUCTS

Sugar beets, potatoes, corn, small grains, alfalfa hay, and livestock are the principal products.

PRINCIPAL MARKETS

Agricultural products from the project are distributed throughout the nation. Sidney, Montana, is the local market center for crops and livestock. Principal out-of-state markets are located at St. Paul and Minneapolis, Minnesota; Chicago, Illinois; Spokane and Seattle, Washington.

LOWER YELLOWSTONE RIVER
S&MC

The Lower Yellowstone Project serves 52,221 acres of irrigable land lying north and west of the Yellowstone River. It is about 60 miles in length and varies up to 5 miles in width. It extends from the Diversion Dam at Intake in Montana to the confluence of the Yellowstone River with the Missouri River in North Dakota.

The river meanders through the valley constantly changing its course and eroding away farmland. A substantial acreage of irrigable land has been lost to the changing stream through the years. In some places it has also destroyed irrigation facilities and endangered other facilities. Some laterals have been moved periodically since development of the project, but are endangered again.

In 1965, a program was initiated to test measures that would at a moderate cost provide a reasonable degree of erosion control along the Yellowstone River. A three-year investigation program funded with General Investigation funds had previously been proposed but it was not funded. In a letter dated August 15, 1966, the Assistant Commissioner suggested that an investigation be made and a report prepared outlining the problems, probable total cost and recommending desirable action. The Commissioner stated that "we feel that the current remedial construction work to protect project facilities, which you are now doing with S&MC funds, should continue at about the present level ($60,000 in FY 1968) until a river management program is authorized."

Providing bank erosion control for the Yellowstone River in the Project area is a formidable task.

In order to be effective, any bank protection installations must be of sufficient strength to withstand tremendous forces during ice breakup and the high flows during June floods as well as the constant pressure of a live flowing river.

Installations which have been placed at eroding river banks to protect Government lands and facilities extend over most of the length of the Lower Yellowstone Project. (See attached map, Drawing No. 14-605-16 on which the S&MC installations have been shown).

A summary of the work accomplished, costs and work proposed follows:

The annual expenditures were:

FY 1965	$ 50,000
FY 1966 & 1967	102,000
1968	104,000
1969	44,000
1970	46,000
1971	67,000

Richland Park and Lateral G Area

Aerial Photo V14-600-95, 141 & 203, Operating Map No. 23 & No. 24.

Work began in 1965 on the Richland Park and Lateral G (Hanson) area in Sec. 13, T. 23 N., R. 59 E., and Sec. 18, T. 23 N., R. 60 E., P.M.M. The lateral had been moved twice and was being threatened again. The river banks were vertical, with easily eroded sand strata in the subsoil. A large jetty known as the Richland Park jetty was constructed in 1965. The jetty was keyed into the bank and bottom. The core of the jetty was gravel filled and then rock covered. About 4,000 yards of gravel and rock were placed in this jetty. It is a large, massive jetty and, except for a few rocks on the point which were moved away by ice, it has held up very well.

The river has deposited a berm along the bank above the jetty which is very desirable.

Immediately below the jetty the banks are still vertical and raw but do not appear to be eroding seriously. Two or possibly three additional jetties or jacks below Richland Park and above Lateral G jetties may be required before this area of river bank becomes stabilized.

About 3,500 feet downstream from the Richland Park jetty lies Jetty No. 1 of the Lateral G (Hanson) series. It was installed in 1966. This relatively small jetty contained about 1,500 yards of rock. Jetty No. 2 lying 1,300 feet below No. 1 was constructed in 1965 and it contained about 3,000 yards of gravel and rock. Because of ice damage and bank erosion some bank sloping was done between Jetties No. 1 and No. 2 in 1972 and another 500 yards of rock were added to Jetty No. 1. Jetty No. 2 had a gravel core covered with rock. It received terrific ice pressure and considerable rock was eroded off the point by ice flows. Jetties No. 3, No. 4, and No. 5 were constructed in 1966 and 1967 with 1,500, 3,300 and 1,500 yards of rock, respectively. Jetty No. 4 had a gravel core and covered with rock. No. 5 was too small and another 500 yards of rock were added in 1972.

There was considerable turbulence around these jetties. In order to minimize the effects of the turbulence, some gravel blanketing has been placed on sloped banks, and car bodies and junk was hauled in (a now illegal practice in Montana) by the Irrigation Districts or the landowner to stabilize the banks. A total of 300 steel jacks were placed to support the jetties in stabilizing the banks.

Experience has shown that jetties are effective in controlling bank erosion for a distance of about three to four times the length of the jetty. Jetties extending 50 to 100 feet from the riverbank should have been spaced at 300± feet intervals instead of the 1,300, 450, 400 and 900 feet intervals in order to achieve optimum protection. The spacings of the jetties now in place were selected in an effort to provide protection to as long a reach as possible early in the

program. It was originally intended that additional jetties would be constructed later.

In the long spaces between jetties, additional bank protection installations such as steel jacks are ordinarily needed.

Lateral PP-3 & Charal Farms

Aerial Photo No. V14-600-81 & 197 and Operating Map No. 13 and 14.

Four jetties were constructed in 1966 - 1967 to protect Lateral PP-3 in Sec. 6, T. 21 N., R. 59 E. All were keyed into the bank and bottom of the river. These jetties were spaced 400 to 500 feet apart with about 3,000 yards of rock each jetty, except No. 4, which had only 1,200 yards. Some bank sloping and 1,000 yards gravel blanketing has been done to help stabilize the banks. At one time, steel jacks were placed between jetties but were not cabled together or tied to the banks. These jacks were soon lost, and this loss pointed up the need for anchoring them firmly if they are to be effective.

The Charal farms area, which is in Sec. 1, T. 21 N., R. 58 E., is part of the Lateral PP-3 system and it is immediately above the original jetties. This area has been eroding severely. During FY 1971 and 1972, the bank was graded to a 3:1 or 4:1 slope for nearly 3,000 feet. It was covered with a gravel blanket.

Mr. Ernie Pemberton, Head Sedimentation Section, Denver, in his trip report of his trip of December 14-18, 1970, wrote:

> At Lateral PP-3, they are now sloping a rather sharp bend on the Yellowstone River and placing a gravel blanket. Trying to control this sharp a bend is almost an impossible problem. The bend now has a radius of curvature of approximately 1,200 feet, which is compared to a mean width on the Yellowstone River in this area of about 800 feet. A normal radius of curvature for a stable channel is a radius equal to 8 to 10 times the top channel width. This would indicate a radius along the Lower Yellowstone River of 6,400 to 8,000 feet. In some cases, this radius can go down to as low as 6 times the width, which would be about 4,800 feet in the Lower Yellowstone River. However, a radius of 6 times the width may require bank control measures. It is realized that this work on the Lower Yellowstone is experimental, and under these conditions the gravel blanket being placed at Lateral PP-3 will provide a test on the scouring action at a sharp bend. With the present slope of the gravel blanket on the 4:1 or 5:1 slope, there is a definite need for protecting the toe of this bank by placing either large rock or large-size jacks.

The need for additional bank protection has been demonstrated as was anticipated. Therefore, four additional rock jetties were installed. The upper rock jetty containing 3,000 yards of rock and the second jetty containing 2,000 yards of rock were keyed into the bottom and banks as they were the key structures. Because of difficulty in working conditions and a lack of a good working base for a dragline, the lower two jetties, containing 1,500, and 1,000 cubic yards, respectively, were not keyed in. This was a calculated risk, but with the gravel blanketing, and 150 steel jacks to be installed and anchored, the river bank should be stabilized.

State Line or Lateral H

Aerial Photo No. V14-600-100, 146 and 209, and Map No. 26.

The area near the State line or Lateral H is situated in Sec. 2, T. 24 N., R. 60 E., in Montana, and Sec. 16, 17, and 18, T. 150 N., R. 104 W., in North Dakota.

Four jetties have been constructed. These, consisting of 2,500 to 3,000 yards of rock each, are keyed into the bank and bottom and have been reinforced with 1, 2, or 3 rows of steel jacks between them. These jetties and jacks protect about one mile of river bank. The next 1½-mile stretch of river bank below the lower jetty has been protected by bank sloping at 4:1 slopes, and covering with a 2- to 4-foot cover of gravel.

The jetties have done their work well but No. 1 and No. 2 have lost some rock off the points because of ice action. Forty-six jacks were lost because of ice action in 1968 and 100 jacks in 1972.

The bank sloping and gravel blanketing on this convex or inside bend is aesthetically attractive and has been relatively effective. However, it was necessary to repair one area where shifting currents or ice damage caused some erosion.

City Lagoon Lateral D Area

Aerial Photo No. V14-600-135, Map No. 19.

The City Lagoon and Lateral D is located in Sec. 2, 3, and 10, T. 22 N., R. 59 E. This has been a joint effort with the irrigation district and city of Sidney. The city has been protecting the bank near the City Lagoon with car bodies, junk, broken concrete rubble, etc. However,

the river was beginning to bypass the makeshift protection by cutting behind. Car bodies have recently been outlawed for this type of riprap in Montana by action of its legislature.

Three rock jetties containing 3,000, 4,000 and 2,000 yards of rock and 200 steel jacks were installed during 1968-1970.

These installations appear to be effective in confining flows in the present channel and in protecting the lateral and the City Lagoon.

Caudill or Lateral KK Area

Aerial Photo No. V14-600-118, Map No. 10

This installation is located in Sec. 12, T. 20 N., R. 58 E. In 1969, during the spring floods a section of Lateral KK washed out. Project forces at project expense rebuilt the lateral and hauled pit run gravel blanket to cover the most erosive area. Then 114 steel jacks were placed along the river bank for erosion control.

These jacks are located on a concave bend of the river with about 2,000-foot radius of curvature.

This stretch of the river is not as unstable nor as subject to bank erosion as the areas downstream. The river banks at normal water levels are gravel and stable, but are overlaid with erosive sands. It is only during ice flows and June floods that damage occurs. The steel jacks are effective in protecting the river during June floods but the ice flows during the spring breakup have twice out of 3 years pushed the jacks upon the banks. The jacks had to be replaced back on the water line. It is evident that a rock jetty or two will be required to protect the jacks from ice damage.

Lateral NN Area

Aerial Photo No. V14-600-75 and Map No. 11

In Sec. 34, T. 21 N., R. 58 E., a small flood channel takes off from the main channel. During high flows, lands are being eroded and Laterals KK-11 and NN are threatened. Attempts are being made to keep this side channel from degrading and to actually cut off the water during all except the high flood flows. The area has a stable gravel base during normal flows but is subject to degradation during high flood flows.

In 1969, 20 concrete jacks and 70 steel jacks were placed in a row across this side channel. The high ice flows broke the arms of the concrete jacks and flattened the steel jacks. Project equipment available for installing the jacks is not large enough to handle jacks of strength and size needed to withstand the ice flows in some years. In 1970, 35 concrete jacks and some steel jacks were installed in the same location. They withstood the ice and flood flows during that year. A large deposit of silt resulted from the installation. In the spring of 1971, however, ice flows again broke the concrete jacks. Although the steel jacks were crushed by the ice, they still retained some of their shape and were partially effective.

It is planned that a rock dike about 600 feet long will be installed across this channel in 1973 at the elevation of the normal flood depth. This should catch ice and silt and help stabilize the channel.

Steel jacks might be used in this situation if two rows were installed and anchored securely by cable to deadmen.

Lateral HH or Burns Area

Photo No. V14-600-62 and Map No. 5.

A short side channel is developing in Sec. 19, T. 19 N., R. 58 E., near Burns siding and is threatening Lateral HH.

Some bank sloping and about 800 yards of gravel blanketing has been installed as a temporary measure. It is suggested that a rock dike about 200 to 300 feet long be installed to prevent further degradation of the side channel.

Various methods of placing the steel jacks are as follows:

(a) One row of steel jacks.

The jacks are placed along the river bank at the normal waterline at 14-foot centers. They are cabled together and anchored about every 330 feet to deadmen in the bank.

(b) Two rows of steel jacks.

A second row of steel jacks is placed higher on the bank and behind the first row. In each row the jacks are cabled together and anchored to deadmen.

(c) One row of steel jacks with rows of jacks extending laterally into the river. The rows of jacks extending out into the river are moved back toward the bank by ice action. They are very effective in catching debris and protecting the banks but are more vulnerable and subject to loss by ice action.

(3) Gravel blanketing - The vertical banks are sloped 3:1 or 4:1 and covered with pit run gravel. At the high watermark, the gravel is about 2 feet deep, and at the normal waterline it is about 4 feet deep. About 28,000 cubic yards of gravel per mile is placed.

Comparative costs of the various installations are as follows:

Rock jetties - 2,000 to 4,000 yards/jetty, at \$6 to \$11/yard = 3,000 yards @ \$8 = \$24,000

Steel jacks - 14-foot centers. One row - 375 jacks/mile @ \$26.00 to \$75.00 each = \$10,000 to \$28,000/mile. Two rows - 750 jacks/mile = \$20,000 to \$57,000/mile.

Gravel blanketing - 28,000 yards/mile @ \$2.20 to \$4.60/yard = \$62,000 to \$128,000 per mile.

Summary of results and recommendations:

1. Additional studies should be initiated on the Yellowstone River to help formulate a total river program. Inasmuch as no funds have been made available to date from other sources, it is recommended that S&MC funds be used starting with \$14,000 in FY 1973 and increased to \$20,000 in FY 1974. These amounts are included in program schedules for contract work with the irrigation districts. This would leave \$60,000 annually for the continuation of river construction work on an interim basis.

These studies would include investigations of specified river sections that are subject to damaging erosion, special sediment measurements, bed and bank material analysis and observations of water surface elevations. The data would be used in determining the advisability for developing additional plans for a continuing bank erosion control program.

Denver and Regional Office review of the area should be made again in 1972 to further evaluate the installations now in place and to develop plans for future work in the immediate future.

2. Present estimates of the usefulness of the erosion control installations in place are as follows:

(a) Rock jetties: These are effective and are an essential component of any bank protection. The length of bank protected is limited to about three times the perpendicular

distance the jetty extends into the river. The jetty points are subject to erosion damage by ice flows, and periodical maintenance is required.

(b) Steel jacks: Steel jacks constructed from three pieces of 4" x 4" x ¼" angle iron 16 feet long as shown in Sketch No. 8 are cabled together toe to toe along the bank. The jacks must be anchored to deadmen buried in the bank at 330-foot intervals if they are to be kept in place. These jacks catch trash and are effective in protecting the banks from erosion during June floods and normal flows. If protected by jetties to divert the direct thrust of ice the jacks make bank protection effective far beyond the distance usually afforded by jetties alone. It appears that a combination of jetties and steel jacks are the most economical combination of effective installations.

(c) Concrete jacks are more expensive than the steel jacks, are heavier and harder to place. They are effective during flood flows but the action of ice breaks off the arms and makes this type of jack ineffective. Steel jacks are better and cheaper under these conditions.

2. (d) Bank sloping: The bank sloping and gravel blanketing is attractive and appears to be effective under favorable conditions. One problem is that the source of gravel does not have the percentage of larger sizes desired.

3. New types of installations that might be considered:

Most of the efforts to date have been to confine the river to its present channel and protect the eroding banks. Additionally, the work has been limited to one side of the river. In some areas undesirable side channels are developing. If further degradation of these side channels can be prevented, extensive erosion control downstream might be averted. It is suggested that further work be scheduled to meet this problem.

Conclusions:

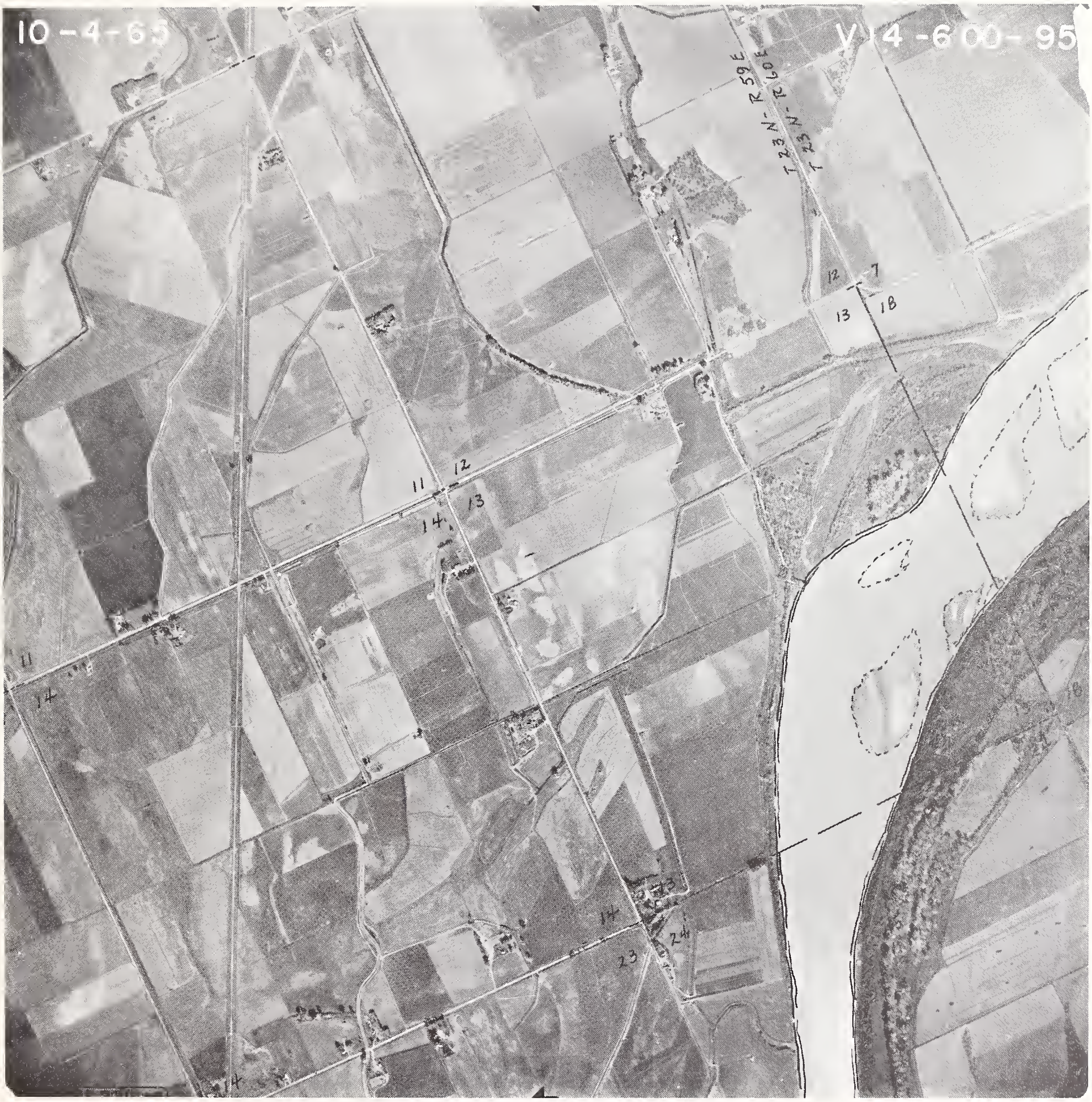
The erosion control work on the Lower Yellowstone has been successful in markedly reducing erosion of the river banks in selected areas of the Lower Yellowstone Project. Several laterals, which were endangered by the river, have been protected.

Areas of land totalling hundreds of acres have been protected from meander, cutoff, or erosion by the river.

The program is so successful that landowners across the river and in other areas constantly contact the districts for similar help.

The installations require maintenance, especially from ice damage, but this work can be done by project forces and equipment.

It is recommended that the program be continued.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10-4-65
Montana
North Dakota
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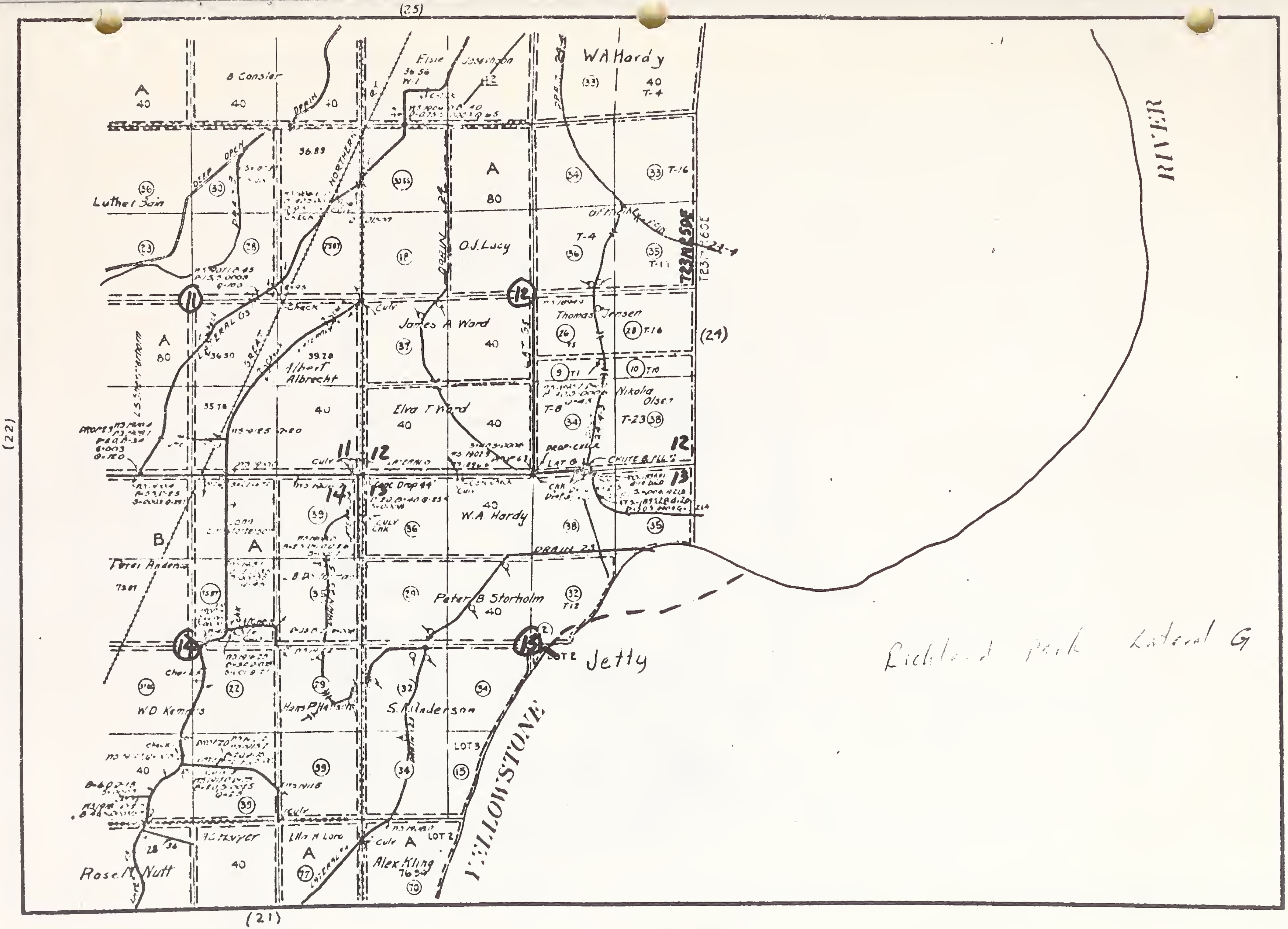
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Albert Albrecht
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W.A. Hardy
Peter B Storholm
Jetty
YELLOWSTONE
RIVER
S.R.Anderson
W D Kemp
Hans P Hansen
Rose M Nutt
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GREAT NORTHERN
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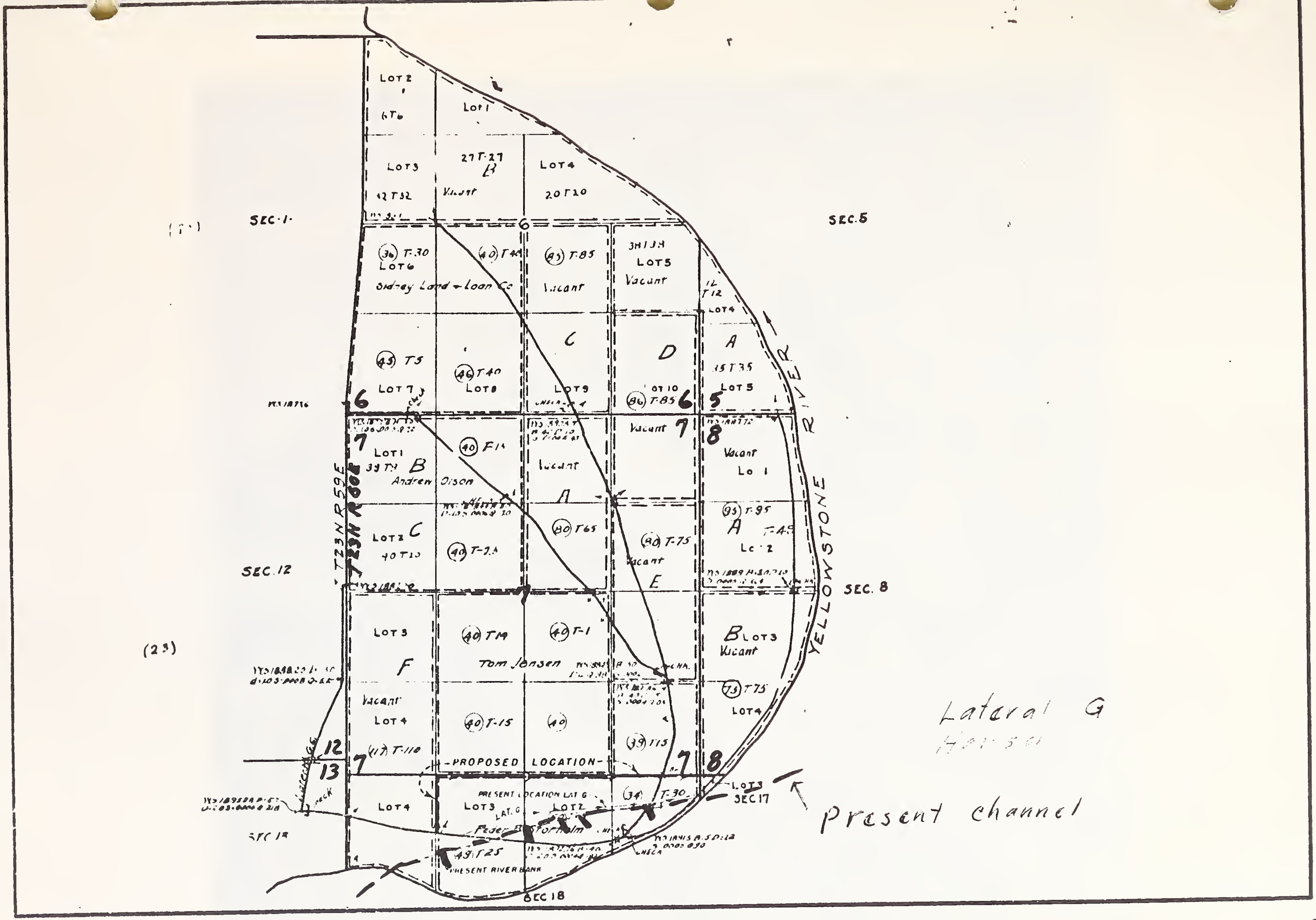
LOT 2
LOT 3
Richland Park Lateral G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SEC. 8
SEC 17
SEC 18
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YELLOWSTONE RIVER
Sidney Land + Loan Co
Andrew Olson
Tom Jensen
PROPOSED LOCATION
PRESENT LOCATION LAT G
PRESENT RIVER BANK
Lateral G
Present channel

T 22 N - R 58 E
T 21 N - R 58 E
T 21 N - R 58 E
T 21 N - R 59 E
Lateral PP3
Lateral PP3
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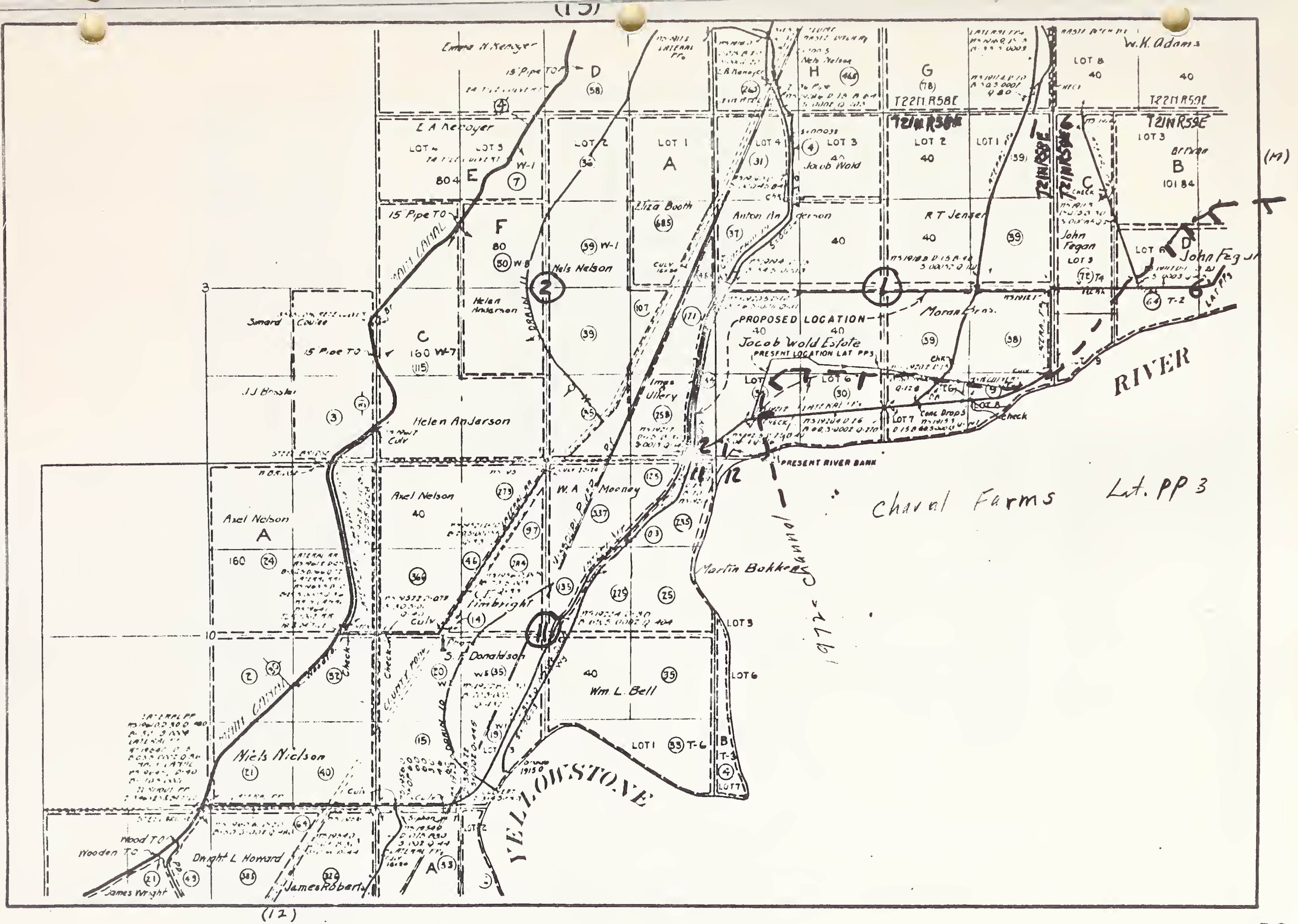
YELLOWSTONE
RIVER
Chaval Farms
Lat. PP 3
1972 Channel
PRESENT RIVER BANK
PROPOSED LOCATION
Jacob Wold Estate
PRESENT LOCATION LAT PP3
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John Fegan
Moran Bros.
R T Jensen
Jacob Wold
Anton Anderson
Eliza Booth
Nels Nelson
Helen Anderson
Imes Ullery
W. A. Mooney
Axel Nelson
C. F. Timbright
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Martin Bokken
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James Wright
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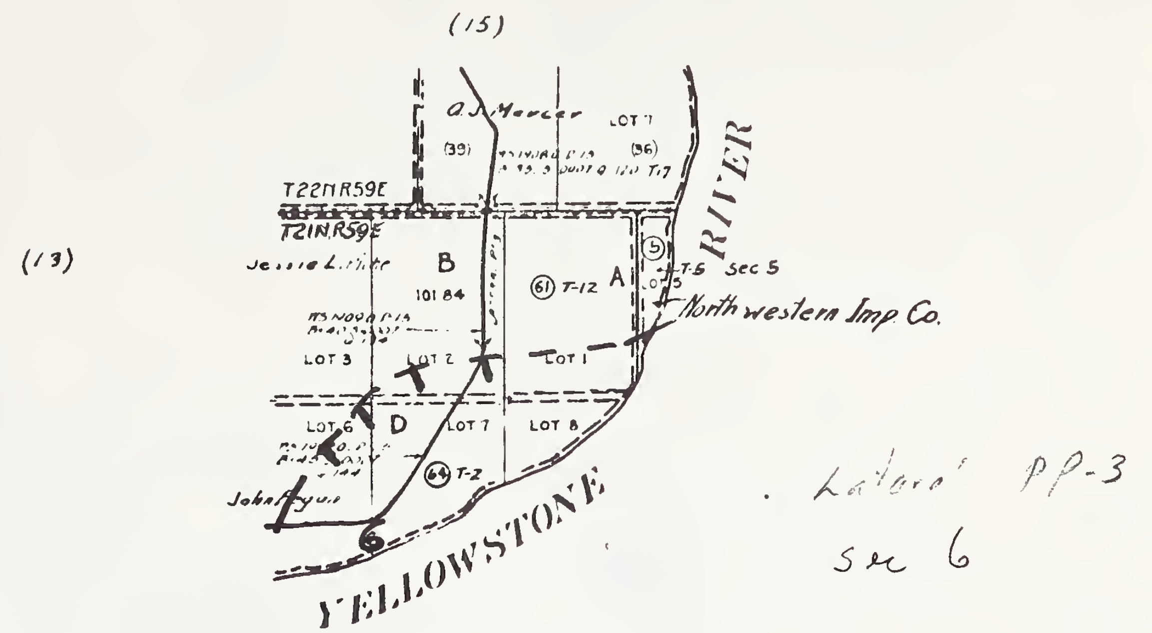
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YELLOWSTONE
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MONTANA
NORTH DAKOTA
Lateral H
T 24 N - R 60 E
T 150 N - R 104 E
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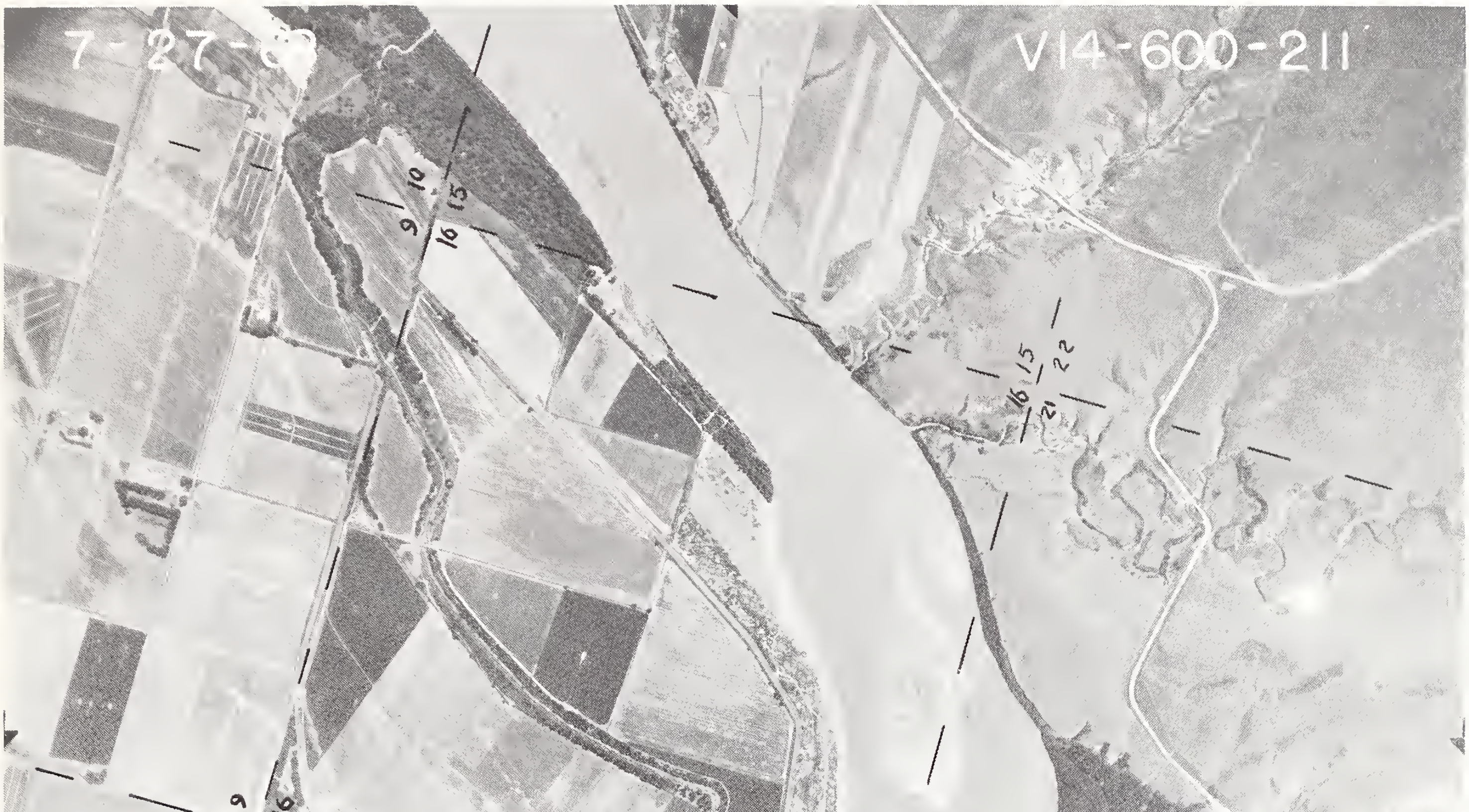
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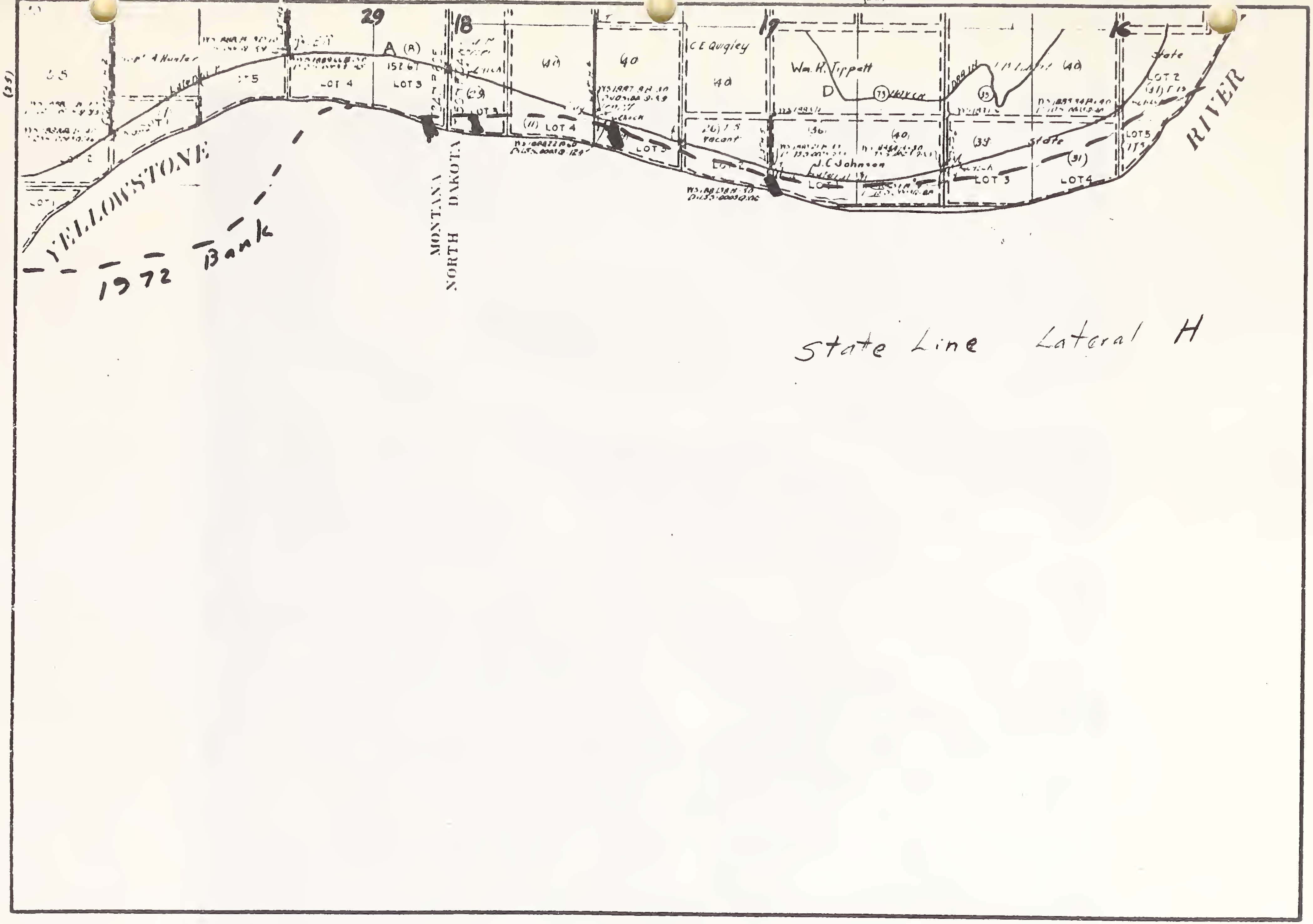
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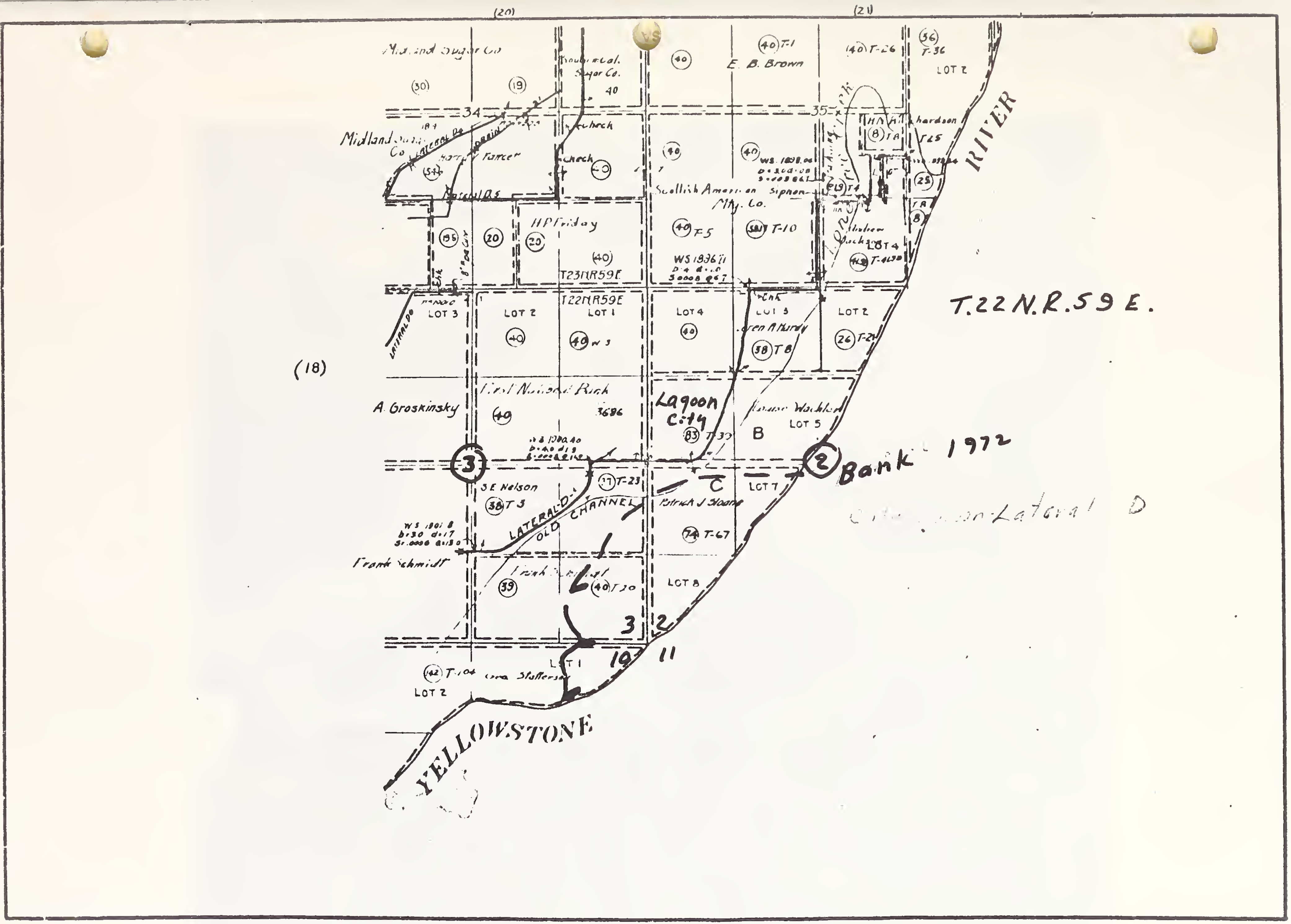

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First National Bank
Lagoon City
Bank 1972
S E Nelson
Frank Schmidt
LATERAL-D
OLD CHANNEL
Patrick J Sloane
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Latera K.K.
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Sec 12 T 20N R 58E
V14 -600-118

Lateral washed out & rebuilt 1969
Jacks paced with same funds.


600-75
Lateral NN
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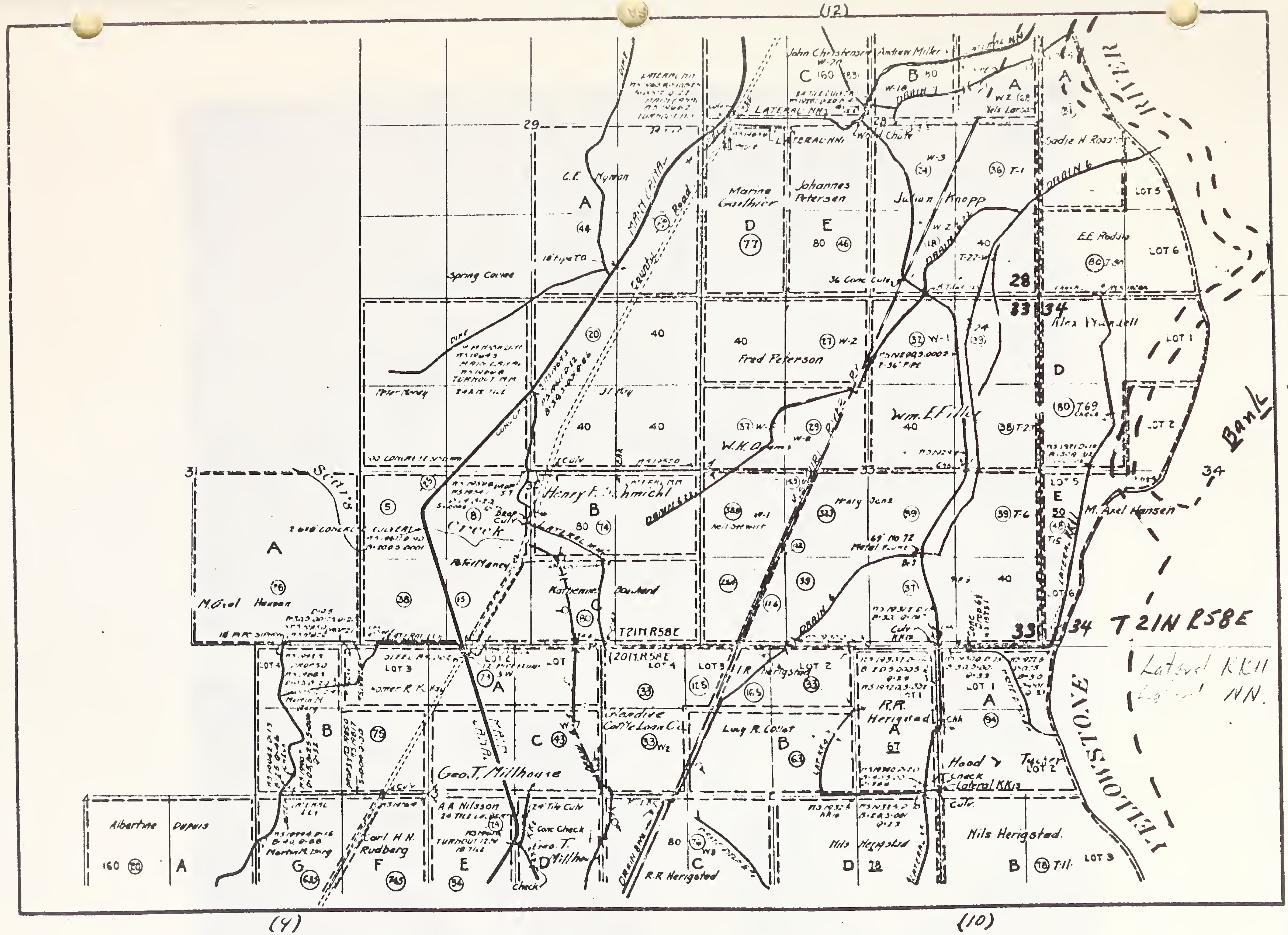
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Marine Gaulthier
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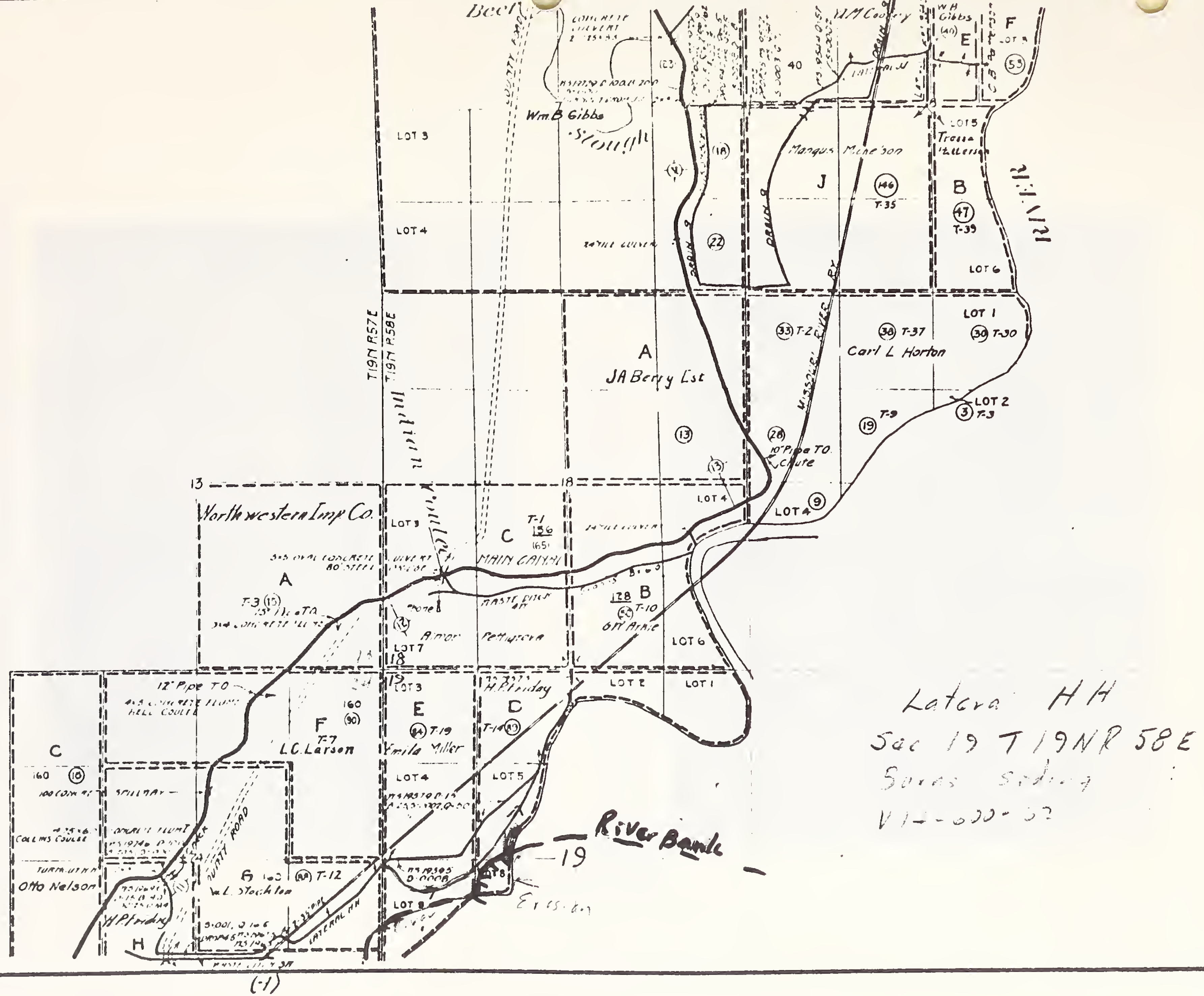
LATERAL NN
DRAIN 6
E.E. Rodda
Alex Wandell
Fred Peterson
Wm. E. Filler
W.K. Adams
Henry F. Schmichl
Scott's Creek
Peter Maney
Katherine Bouchard
Mary Danz
M. Axel Hansen
M. Axel Hansen
Homer R. McKay
Geo. T. Millhouse
Glendive Cattle Loan Co.
Lucy R. Collet
R.R. Herigstad
Hood & Tucker
Lateral KK12
A.A. Nilsson
Carl H.N. Rudberg
Martin M. Berg
Nils Herigstad
R.R. Herigstad
Albertine Dupuis
28
33
34
29
31
LOT 1
LOT 2
LOT 3
LOT 4
LOT 5
LOT 6


14-600-62
T19N-R57E
T19N-R58E
LAT HH
13
18
19
24
17
20
23
25
26
30


Lateral HH
Sec 19 T19N R58E
Wm B Gibbs
Slough
Manqus Mikelson
Carl L Horton
JA Berry Est
Northwestern Imp Co.
Indian Coulee
MAIN CANAL
LC Larson
Emila Miller
H.P. Friday
Otto Nelson
W.L. Stockton
River Bank
Erosion
RIVER
T19N R57E
T19N R58E
LOT 1
LOT 2
LOT 3
LOT 4
LOT 5
LOT 6
LOT 7
LOT 8
10" Pipe TO Chute
12" Pipe TO
SPILLWAY
LATERAL HH
DRAIN B
W.H. Gibbs
W.M. Cowley

P14-600-368NA--Lower Yellowstone S&MC--May 7, 1970. Richland Park jetty. Berm formed above jetty which was constructed in 1965.

P14-600-369NA--Lower Yellowstone S&MC--May 7, 1970. Below Richland Park jetty. Shows effects of ice flows on large willows.

P14-600-365NA--Lower Yellowstone S&MC--May 7, 1971. Lateral G - Hanson area. Rock jetty with point eroded by ice flows.

P14-600-344NA--Lower Yellowstone S&MC--May 7, 1971. State line-Lateral H area, bank below second jetty stabilized by steel jacks. Note vegetation.

P14-600-371NA--Lower Yellowstone S&MC--June 9, 1970. River bank in Lateral PP-3, Charal Farms area.

P14-600-372NA--Lower Yellowstone S&MC--December 16, 1970. Yellowstone River after bank sloping in Lateral PP-3 Charal farms area. Material for gravel blanketing and some jacks are in background.

P14-600-364NA--Lower Yellowstone S&MC--1966. A typical vertical bank along river near State line. Sand strata in profile erodes easily.

P14-600-335NA--Lower Yellowstone S&MC--June 1970. Yellowstone River bank near State line has been stabilized by rock jetties and steel jacks.

Lower Yellowstone--S&MC--March 1969. Ice piled at rock jetty during spring breakup.

Lower Yellowstone--S&MC--March 1969. Ice deposited on sloping banks in State line area by high flows.

P14-600-341NA--Lower Yellowstone S&MC--May 7, 1971. Stabilized area between jetties No. 3 and 4 State line. Silt has been deposited as a result of steel jacks placed between rock jetties.

P14-600-367NA--Lower Yellowstone S&MC--April 21, 1969. Jacks crushed by ice but still effective - below Jetty No. 1 - State line area.

P14-600-366NA--Lower Yellowstone S&MC--June 9, 1970. Area below rock jetty stabilized by bank sloping and gravel blanketing near State line.

P14-600-292NA--Lower Yellowstone S&MC--June 12, 1968. Completed bank sloping and gravel blanketing near State line.

14-600-334NA--Lower Yellowstone S&MC--August 12, 1969. Silt deposited below middle jetty in City Lagoon Lateral D area.

P14-600-363NA--Lower Yellowstone S&MC--May 6, 1971. Steel jacks buried by silt below upper rock jetty--City Lagoon Lateral D area.

P14-600-370NA--Lower Yellowstone S&MC--May 6, 1971. Lateral KK - Caudills - During spring breakup the ice forced the jacks up onto the banks.

P14-600-287NA--Lower Yellowstone S&MC--January 30, 1969. Steel jacks - ready for installation. 4" x 4" x $\frac{1}{4}$" angle iron - 16 foot long members welded together and wired with #6 wire.

P14-600-375NA--Lower Yellowstone S&MC--March 19, 1970. Lateral NN. Concrete and steel jacks in place in a side channel of river. The purpose of this type of installation is to reduce bottom degradation of such overflow channels.

P14-600-376NA--Lower Yellowstone S&MC--June 9, 1970. Lateral NN. Concrete jacks during high flows. Jacks were effective this year.

P14-600-373NA--Lower Yellowstone S&MC--May 6, 1971. Lateral NN - concrete jacks crushed by ice in spring.

P14-600-374NA--Lower Yellowstone S&MC--April 21, 1969. Closeup of concrete jacks crushed by ice. This type of jacks in sizes which can be handled by Project forces has proven ineffective.